REMARKS/ARGUMENTS

Claims 47-74 now stand in the present application, claims 1-30 having been canceled. More particularly, new claims 47-74 substantially reflect claims 1-30 rewritten to more completely define Applicants' invention and to overcome § 112 deficiencies noted by the Examiner. In addition, the specification has been carefully reviewed and appropriate editorial corrections have been made. Reconsideration and favorable action in this case is respectfully requested in view of the above amendments and the following remarks.

In the Office Action, the Examiner has objected to claims 1, 10, 12, 22 and 24-27 for a number of informalities. As noted above, Applicants have submitted a new set of claims which are believed to correct all of the technical deficiencies pointed out by the Examiner with respect to the original claims. Accordingly, the Examiner's objection to the claims is believed to have been overcome.

The Examiner has also rejected claims 1 and 5 under 35 U.S.C. § 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which Applicants regard as the invention. As noted above, Applicants have amended the claims so as to correct the § 112 deficiencies pointed out by the Examiner. Accordingly, the Examiner's § 112, second paragraph, rejection of claims 1 and 5 is believed to have been overcome.

The Examiner has also rejected claims 1-5, 8-13, 20-23 and 26-28 under 35 U.S.C. § 103 as being unpatentable over Pollak and has rejected claims 6-7, 14-19, 24 and 25 as being unpatentable over various combinations of Pollak and Webster or

Pollak '145, and has rejected claim 29 under 35 U.S.C. § 103(a) as being unpatentable over Pollak in view of Starcke et al. In view of the above-described claim amendments, the Examiner's § 103 rejections of the claims are believed to have been overcome, as will be described in greater detail below.

Prior art methods for producing colored gemstones, such as powder diffusion, did in fact provide colored gemstones but suffered from several disadvantages. For example, R.R. Carr and S.D. Nisevich, U.S. Patent No. 3,897,529 (1975) teaches the contacting of a coloring agent with a gem mineral. The coloring agent is used in powder form and surrounds the gemstone completely. There are also several other subsequent patents and technical literature relating to improvements in powder diffusion method for enhancing colors or imparting colors to gemstones (Ref: R.E. Kane et al., Gems & Gemology, Summer 1990, and Summer 1993).

Pollak, unlike Applicants' thin film coating process, discloses a powder diffusion method that suffers from substantially the same number of limitations and drawbacks as the prior art diffusion methods enumerated above:

(i) Different steps of heating and cleaning are required

(ii) Surface damage occurs to treated stones.

(iii) Uneven coloration — partly a result of the surface damage to the gemstone and partly since it is difficult to control the exact amount of powder diffusing into the gemstone.

(iv) Low yield

(v) Low throughput

(vi) Production cost

(vii) Powder diffused gemstones require subsequent polishing and cleaning since the powder may still remain adhering to the surface of the gemstone and due to surface damage - resulting in reduction in the gemstone weight, reduction in color intensity and enhanced costs.

Powder diffusion, as disclosed in Pollak, requires that the gemstone be completely immersed in the coloring agent powder. This obviously has the limitation that if multi-colored or bi-colored gemstones are desired, the process has to be repeated with different coloring agents in powder form. The added disadvantage is that it is difficult to control the exact level of diffusion of the powder. In addition, the powder is larger in size that the pores on the gemstone surface. Thus, as the powder attempts to diffuse into the crystal lattice, the surface of the gemstone is damaged.

Other problems with powder diffusion technology are that a thermal budget has to be designed to develop the desired level of diffusion. Temperature limits for a reasonable diffusion time are determined by the value of a diffusion constant of a dopant element (which strongly depends on temperature) in the host solid. The highest temperature of diffusion is restricted by the temperature to which the host material can withstand and on the consideration of solid solubility of die dopant material in it. Since at a low temperature, the value of diffusion constant is significantly small, a compromise has to be made in selecting lowest temperature of diffusion processes and diffusion time. A lower temperature requires a long time for diffusion. This does not suit a colored gemstone production process.

It is known in the art that colors in gemstones are caused due to the presence of minor amounts of impurities. Thus, a minor amount of dopant is required to impart the

desired color to the gemstone. What is important is to obtain a control over the amount of coloring agent, which diffuses into the gemstone. In Pollak's method, the gemstones are buried in powder of a treating agent. As a result, there is no control on the supply of colorant atoms diffusing into the crystal during thermal treatment, except the exposure time. In actual practice, treated gemstones in the Pollak process are either green or greenish-blue when cobalt is used as the colorant. In order to obtain a pure blue or a desired shade of blue by Pollak's method, it is essential to subject the gemstone to a second heat treatment in the absence of a treating agent.

Another disadvantage of the powder method of Pollak is thermal mass involved in the coloring process. In the case of Pollak's process, gemstones are heated in combination with treating powder. Therefore, the furnace load consists of gemstones and powder, thereby increasing the thermal mass in furnace. This results in increased power consumption per thermal treatment cycle. Thus, the powder diffusion method consumes expensive furnace time and power for treatment of the gemstones. Further, the powder does not only load the furnace thermally but also occupies additional space in the furnace.

Pollak's methods require <u>a higher treatment temperature and longer exposure times and/or additional thermal treatment</u>, as compared to Applicants' claimed process, which also adds to the cost of production. Moreover, Applicants' film deposition process obviates the above drawbacks cited with respect to the Pollak method.

The objective of the present invention was to develop a cost-effective and time-effective process by minimizing drawbacks of the powder diffusion methods. Applicants' concept of <u>implementing film for coloring gem minerals</u> in the present invention has

resulted in the development of cost effective processes. The thin film based coloring process, disclosed and claimed in present application, not only obviates the limitations and drawbacks encountered in Pollak's powder method but also offers many qualitative and quantitative advantages for production of colored gemstones. For example, thin film contacting results in significantly short thermal exposure times for treatment, reduction in thermal and cleaning steps, saving in furnace power and increase in production per treatment cycle. Additionally, thin film processes are clean and eco-friendly.

Surface damage does not occur since a defined area of the gemstone is coated with the film and then subject to a single hear treatment. For example, the entire gemstone may be coated with a single film or separate parts of the gemstone may be coated with films of different coloring agents, to obtain multi-colored gemstones. Some examples of the stones obtained by the process of the instant invention are given in color pictures 1 and 2, attached hereto.

Another advantage of Applicants' invention is that control over the amount of coloring agent is obtained by simply controlling the thickness of the film coated onto the gemstone. Thus, desired intensity and depth of color in the gemstone can be obtained without requiring further monitoring or heat treatment to enhance color intensity.

A third advantage of the instant invention over Pollak is that the entire coloring agent is consumed. In Pollak, it is evident that powder will remain either within the furnace and also adhering to the surface of the gemstone. This does not occur in the instant invention. As a result, there is no surface damage to the gemstone when the instant method is used and wastage of material is avoided. An important consideration for selection of the temperature and time ranges, in the present invention, is complete

consumption of film material after treatment. Thus, whole film material is consumed in coloration of the gemstone causing no wastage of material at all after treatment in the temperature and time ranges. This further leads to no remnants of unreacted or partially reacted material on the surface of treated gemstones. Consequently, unlike Pollak's process, post treatment cleaning/polishing is not required and no damage is caused to the surface of the gemstones. Examination of surface of treated gemstones of the film processes of the present invention by Atomic Force Microscopy, revealed no irregularity on the surface on nano-metric scale. Treated gemstones are highly uniform in color with excellent surface finish. The surface finish is limited by the quality of the polish of the gemstones prior to the coloring process and not by the coloring process.

Another significant advantage of Applicants' thin film process is that the film material neither adds to the thermal mass nor requires additional space in the furnace. Thus, unlike a powder process, the furnace load per thermal treatment cycle is not limited by the treating agent. Another advantage is that different stones with films of the same coloring agent, or with films of different coloring agents, or even gemstones with different and discrete films applied thereto can be treated in one thermal treatment cycle. hence film processes are not only less expensive than the powder method but also result in higher yield per treatment cycle. Thus, in no way can the Pollak method be deemed to be "equivalent" to Applicants' thin film process.

In Applicants' thin film process, overall thermal exposure times are considerably reduced. Since a thin film is atomically deposited in vacuum, the atoms of colorant are in intimate contact (at atomic scale) covering 1000/o of the gemstone surface to be diffused. When the film coated gems are subjected to heat treatment, they rapidly attain

thermal equilibrium with the furnace ambient and start diffusing into the crystal. Only a predetermined heat treatment cycle is employed to ensure that the entire film material diffuses into the gemstone to provide the desired color. This results in reduced treatment times. In contrast, the Pollack process requires a larger treatment time, *inter alia*, due to the finite distance between the treating agent particles and the gemstone surface.

Another important feature of the present invention is the easy control to vary color/shade of the gemstones. This is achieved by employing a suitable multi-elemental film material. This is done by atomically miring two or more elements during film deposition, the resulted color of the treated gemstones is highly uniform and repeatable. Further, the color shade and intensity is controlled by film thickness and composition in the present invention, whereas, in Pollak's methods, generally a higher treatment temperature and longer exposure times and/or additional thermal treatment are employed, thereby adding to the cost of production.

As pointed out above, the Pollak process requires <u>two heat treatment cycles</u> to obtain optimum diffusion of the coloring agent into the crystal. This is not required in the instant invention, which uses a <u>single thermal cycle</u>.

It is also well known that fine particle size powders involve safety concerns. The powder methods of coloring gemstones employ powders as treating agents. Thus, specific safety measures need to be observed. The importance of such safety measures can also be seen by the US *EPA* program on study of hazardous impact of fine powdered materials on human health and environment. The web reference is given below:

http://news.nanoapex.com/modulee.php?nameNews&file=article&sid3592

Applicants' thin film process on the other hand is considerably safer for both human health and the environment.

Starcke et al US Patent 5,853,826 admittedly discloses PVD/CVD/sputtering to coat films on gemstones pavilion. Similarly, there are other literature references including patents on colored coating, anti-reflection coating, multi-layered films on display devices for aircraft and the like, on glass and transparent objects. However, Applicants respectfully submit that it is an error for the Examiner to hold that the present invention is an obvious combination of Starcke and Pollak. Impurity diffusion by heat treatment is well established for more then 50 years.

Starcke et al. refers to a process of sputter deposition of various combinations of different elements on the pavilion of gemstones, which results in appearance of multi-colors in gemstones because of optical interference. The gemstones produced by this method are referred to as "as deposited" or "coated gemstones." Starcke et al. does not involve any post heat treatment and the product obtained is a gemstone which appears to have mixed colors, and not distinct and discrete colors as obtained by the present invention. Pollak's patent refers to a process involving burying gemstones in a powdered coloring agent and heat-treating this combination in a furnace to produce diffusion treated, or diffusion bonded gemstones.

Thus, there is thus no motivation to combine Pollak and Starcke together apart from the fact that both relate to gemstones. Starcke deals with optical effects being obtained by sputter deposition of different agents on the pavilion of the gemstone while Pollak teaches diffusion into crystal of the coloring agents.

The film based process of Applicants' invention significantly differs from that of Starcke et al. The Starcke et al. process is concerned with deposition of multi-layers of different materials using reactive sputtering to get colors through optical interference. In the present invention, a multi-element thin film is obtained by atomically mixing two or more elements during deposition in vacuum. These multi-element films impart a variety of colors and color shades of a color with unprecedented control to gemstones. Since colorant agents atoms (in a multi-element film of the present process) are distributed uniformly on the gemstone surface, the resultant color in treated gemstone is highly uniform. In this process, the elements to be mixed atomically to get different shades/colors are carefully selected with the objective of not just imparting different shades of the same color but also to produce diffusion treated colored gemstones which are technically more durable than the "as deposited" or "as coated" gem stones.

A mere combination of the Starcke method with Pollak method or any variation thereof, will not result in Applicants' claimed thin film process for the production of gemstones. In addition, there is no guidance or motivation for a person skilled in the art to combine Pollak with Starcke, at least not for the purpose of obtaining gemstones with enhanced/imparted color with no surface damage, and uniform color. Another significant difference between Pollak and/or Starcke and the Applicants' invention is that the coloring agent in the present invention is deposited at the atomic level. This enables the coloring agent to diffuse evenly into the crystal lattice of the gemstone and provide uniform color and intensity without requiring any further treatment.

It should also be clear, from the above discussion, that the other cited references do not solve the deficiencies noted with respect to Pollak and Starcke.

Therefore, in view of the above amendments and remarks, it is respectfully requested that the application be reconsidered and that all of claims 47-74, now standing in the application, be allowed and that the case be passed to issue. If there are any other issues remaining which the Examiner believes could be resolved through either a supplemental response or an Examiner's amendment, the Examiner is respectfully requested to contact the undersigned at the local telephone exchange indicated below.

Respectfully submitted,

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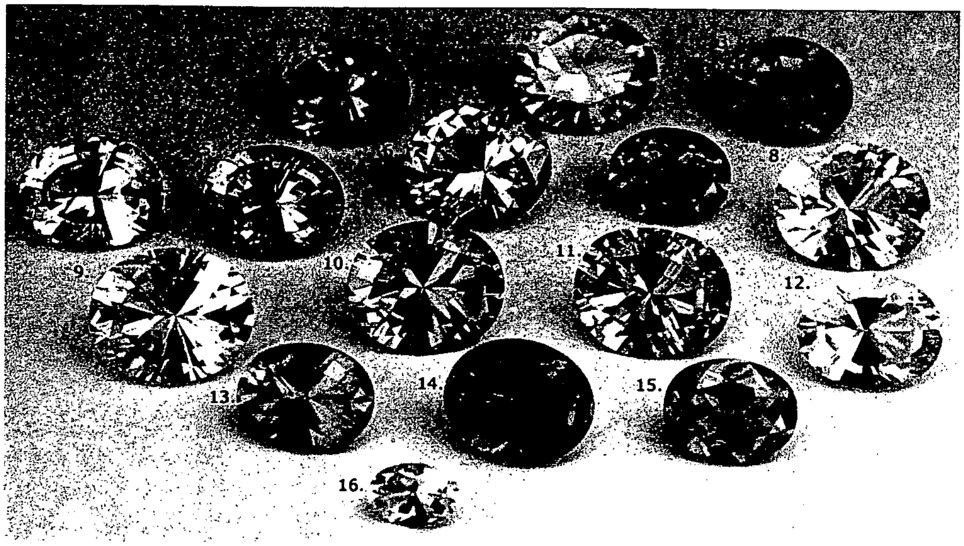
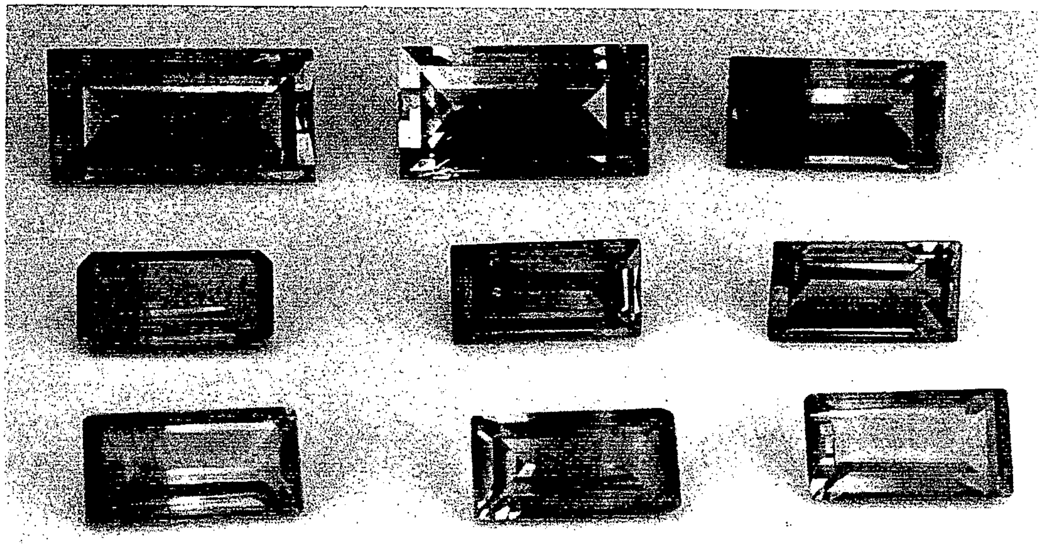


PICTURE 1: COLORS IN TOPAZ TREATED BY THIN FILM DIFFUSION

1. Greenish Black	2. Green Blue
3. Greenish Brown	4. Steel Green
5. Golden Black	6. Medium Blue
7. Green - Shade 1	8. Ice Blue (Light Blue)
9. Ice Blue (Light Blue)	10. Green Blue
11. Medium Blue	12. Aquamarine Blue
13. Green - Shade 2	14. Orange-Red
15. Green - Shade 1	16. Swiss Blue



PICTURE 2 : MULTI-COLORED TOPAZ TREATED BY THIN FILM DIFFUSION PROCESS